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Eighth grade.—The special industries of this grade will be wood- and metal-work. The children will build an out-of-door play-house to be used by the entire school for social purposes. In the furnishing of this house all the other grades will share. The eighth grade will also do some work with metals. They will study the architecture of our city and see what advantage we have taken of our topography—in comparison to other cities—a prairie city and the tenement-house problem. This involves some study of the structure and functions of the city government.

Inquiry as to the causes of congestion of population here will lead to a study of the westward movement of our people, foreign immigration, and the specialization of industries. The occupation of different physiographic regions, with the resulting differences in industries, furnishes the underlying conditions for an understanding of our political history. The following topics are suggested: the Appalachian barrier and routes of travel across it; settlement of Kentucky; life in the Northwest Territory; a typical settlement; the city of Washington and the new government; transportation and demand for roads to the East; political separation between the East and the West; the Cumberland road and the Erie canal; the steamboat and the railroad; the wheat industry and the unification of the North; the cotton industry and the unification of the South; political separation between the North and the South; the mining industry; the factory system of labor and its effect upon the worker; our national ideals; an ideal nation.

Those of the pupils who study Latin will trace the development of Roman institutions, with constant comparisons between the Roman democracy and the American. By this means they will gain an additional impression of the value of the principles of liberty and law.

APPLIED MATHEMATICS.

GEORGE W. MYERS.

PURSUANT to the thought that most elementary and secondary school-teachers of the mathematical subjects will have to do for the most part with students who study mathematics for its uses, the work for the year in mathematics for the professional school will begin with a course in elementary astronomy. Chief emphasis will rest upon the elementary mathematical relations involved in the study of the earth as an astronomical body. Observational data which will be collected during October and November will furnish both a basis and a stimulus for a degree of proficiency in the knowledge and uses of arithmetic, algebra, and geometry. These subjects will be thoroughly restudied during the rest of the year.

One reason for this procedure lies in the fact that, unless a clear conception of the real necessity and purpose of elementary mathematical study, as well as a fair degree of academic knowledge, is first secured, the study of methods of presenting mathematical truth is about as likely to be harmful as helpful. A little superficial expertness in method, manipulation, and method talk is the mask under which an immense deal of slipshod class work is tolerated nowadays. Fluency of speech about ways of presenting truth, without any particular concern about the truth itself, has made more reputations for schoolmasters during the last ten years than will be made by similar tactics in the next ten. It is believed that the truly successful method of presenting any subject must draw the elements of its success largely, if not mainly, from the nature of the subject-matter and the attitude of the teacher's mind toward it. There is no one best method of teaching mathematics. There are as many best methods as there are successful mathematical teachers. This merely means that each teacher must evolve his own method. If he is unable to do this, he would better change his calling.

To do this, however, requires that each prospective mathematical teacher shall do some real work which makes a demand for mathematics. He cannot afford to follow the example of the virulent foes of mathematical teaching of every sort, good, bad, and indifferent, by studiously avoiding, or evading, every social, industrial, or scientific question which makes a positive demand for mathematics. He should remember that, while we may expect to meet mathematical cripples here and there, it is a little unusual for the cripple to argue that sound and sane minds would be just as well or better off by crippling them with their own shortcomings; or that treatment adapted to the cripple is the treatment to be advised for healthy folk. It would be the part of wisdom to ignore the criticisms of such mathematical delinquents, were it not that the contagion of their criticisms is likely to become epidemic, inasmuch as they are on the side of indulgence of mental languor which is always in good standing with those whom circumstance or the accidents of birth have deprived of the necessity of troubling themselves overmuch with virile thinking.

Most authorities on the teaching of mathematics seem pretty well agreed that the need for mathematics arises out of the necessities of measurement. Few of them, however, have pointed out that there are two very different kinds of measurement, *direct* and *indirect*, making very different demands for mathematics. The amount of mathematics actually demanded by direct measurement is ridiculously small. Good judgment will do as much here as any amount of mathematical skill. But with indirect measurement, where some magnitude is wanted which cannot be directly measured, but must be inferred from certain discoverable relations it bears to some other magnitude which can be measured, mathematics is indispensable. Such are the measurements on which the engineering, industrial, and mechanical professions are founded, and such are the professions which constitute the chief part of the difference between what we call civilization and barbarism.

Experience has shown that the best way of breaking the rigors of mathematical apathy which have caught and atrophied many teachers' minds is by introducing the work with a number of practical exercises which bring out the advantages of the mathematical sense. The problems which naturally arise in elementary astronomy have been found to furnish a convenient avenue of approach to the teaching of the need and purposes of mathematical study. Most of the problems wear at least the semblance of the natural, *i. e.*, they have the advantage of not seeming to be lugged in to do the service of the mental vaulting horse, or trapeze, and their solutions usually lead to interesting and intelligible results.

The work will be given through observation, computation, measurements, and lectures, in such proportions as the necessities of the situation seem to require.

I. General directions and plans for the quarter.

1. Field work with home-made instruments.
2. Making of these instruments.
3. Constellation study.

4. Class-room work. (*a*) Discussion and reduction of observational data. (*b*) Recitations on assigned readings. (*c*) Lantern-slide lectures.

II. To obtain definiteness in judging of such magnitudes as are involved in astronomical measurements.

1. To determine the length of the pace: (*a*) Stake out a square acre and pace its perimeter. Obtain length of your pace. (*b*) Measure and stake out over rough ground a distance of 100 to 200 feet. Pace it. Find and record the length of your pace, if possible up a 5 per cent. to 10 per cent. grade and down same grade.

2. To obtain working estimates of angular magnitude: (*a*) Find the angle subtended at the eye by two inches held arm's length and perpendicularly to the sight line. (*b*) Find and record the angle subtended by the palm and each of the fingers held at arm's length of the hand you use most. (*c*) Measure some angles between remote objects by aid of the palm and fingers. (*d*) Measure these same angles with instruments to find your errors and correct your judgment. (*e*) Measure in this crude way the angles between bright stars, planets, etc., the altitude of the sun as so many hours or minutes high, etc., and compare with the correct values (sea led from a celestial globe).

NOTE.—If a great circle be conceived as drawn on the sky from Polaris perpendicularly to the meridian, it will pass through the east and west points of the horizon, and may be called the *6 o'clock line;* because whenever the sun is on this circle it is 6 o'clock. Measuring with the palms perpendicularly from this circle to the sun, pretty fair estimates of the time from 6 o'clock can be obtained.

3. To obtain a judgment of level lines and of the position of the horizon: (*a*) Find and record in your notebook the height of your eye. (*b*) Mark on a tree or other object a point on a level with the eye and fix in mind how a point on a level with the eye looks. (*c*) Locate a half-dozen or so points on a level with the eye by estimate, and measure their difference of level (allow for rise of ground) to find the error of your estimate, and correct your judgment. (*d*) Repeat this exercise until your estimates have some certainty.

4. To form a judgment of the appearance of a vertical line and of the situation of the zenith, or point directly overhead: (*a*) Stand at the middle of the end of a house and note how the head must be held to enable you to look straight up at the comb. (*b*) Plumb down from some elevated point to the point on the ground exactly beneath. Standing upon the ground point, look up at the elevated point. Fix the appearance in mind. (*c*) Take station by estimate under an elevated point, then plumb down from the elevated point and find your error. (*d*) Take occasion some evening to locate by guess the point of the sky which seems at the zenith with reference to stars. Then locate the zenith by sighting up the corner of a building, and find the nature and amount of your error. Face in various directions while making your estimates.

5. Discuss the observations thus far made.

6. To erect quickly an approximate perpendicular to a line from a given point on the line: (*a*) Use the hands only, after first estimating by the eye. (*b*) Use the 6–8–10 method of the carpenter. (*c*) Use the method of equal oblique lines. (*d*) Check (*a*) by (*b*) and (*c*), and work with (*a*) until your results show internal accordance.

7. To find the height of a tree, building, hill, or other object : (*a*) by estimate; (*b*) by length of shadow and rule of three; (*c*) by a stick and rule of three; (*d*) by measuring a base line and two angles.

III. The making of instruments needed for more accurate measures : (*a*) Make a plane table according to specifications which are furnished. (*b*) Make or buy a tripod for it. (*c*) Make an alidade for use with it. (*d*) Make a water level; (*e*) a stadia; and (*f*) a cross-staff, as furnished instructions direct.

IV. To obtain a working familiarity with certain fundamental laws of indirect mearsurement.

1. To find any dimensions of inaccessible objects, distances known: (*a*) by the use of stakes, or flagpoles and rule of three; (*b*) by means of the extemporized plane table and alidade; (*c*) by aid of the home-made stadia.

2. To find by indirect measurements the distances to inaccessible though visible objects: (*a*) by means of flagpoles and tape only; (*b*) by means of crude plane table, one distance measured; (*c*) by more accurate instruments.

3. Derive experimentally the law connecting the distance and apparent dimensions of a remote body. (*a*) An experiment to show how distance to moon is found. (*b*) Discussion of the actual problem of finding lunar distance.

V. Lantern-slide lectures on the topics being studied.

1. The principal movements and relations of the earth to the sun. (*a*) Changes of day and night. (*b*) Changes of the seasons. (*c*) Simultaneous differences in local time. (*d*) Motion of the earth around the sun. (*e*) Apparent motion of the sun among the stars caused by this real motion. (*f*) Apex of the earth's way. (*g*) At what times of day is an observer on the front of the earth? on the rear? (*h*) Point to apex of earth's way.

2. Relations of the earth and moon. (*a*) Phases and their causes. (*b*) Aristotle's method of finding the distance to sun. (*c*) Do we ever see entirely around the moon? (*d*) Librations. (*e*) Surface features. (*f*) Popular superstitions. (*g*) Literary inaccuracies.

Facts and properties relating to the earth as a separate astronomical body.

VI. Shape of the earth.

1. Manner of disappearance, or reappearance, of vessels at harbors. Vessels on a flat earth would disappear and reappear. It is not the ***fact***, but the ***manner***, of disapperance that is important.

2. Relative lengths of shadows of the same object at different places on a flat earth. Can you give any certain evidence that the lengths of shadows do not conform to this theory?

3. Circumnavigation of the earth. Precisely what does the mere fact of circumnavigation of the earth prove? Could a flat earth be circumnavigated?

4. Appearance of horizon as the observer rises. Disregarding the distance from the observer to the horizon, what does the circular form of the horizon show?

5. Modify these four arguments as to the earth's form so that they will prove, not only that the earth is not flat, but that it is globular.

6. Analogy of other planets, and sun. Can any evidence come from earth's analogy to the moon?

7. Shadow of earth on moon at times of eclipse. Lunar or solar? Can the entire shadow of the earth be seen on the moon's disk at one time?

8. Rate at which the pole star rises on going northward on a meridian. Precisely what does this show?

9. Changing position of the observer's zenith as he moves northward or southward on a meridian.

10. Pendulum experiments. Does this argument show anything more than that the earth is approximately spherical?

11. What argument comes from the hypothetical molten primitive nebulous condition of the earth?

12. Are any, or all, of these arguments convincing to your mind? Select those that appeal to you as strong, and point out the ways in which the rest appear inadequate.

VII. Size of the earth.

1. Circumnavigation.

2. Review the remaining arguments on the earth's shape to ascertain whether they also bear on the question of the earth's size.

3. Select and measure a line a mile or so long lying along the shore of a lake, or the bank of a river, and from the amount by which the level line between the ends drops below a stake cut off at the height of the end stakes above the water, compute the size of the earth.

4. A comparison of the length of a meridian measured in miles with its length in degrees.

5. Let a 30-inch globe represent the earth. How thick must a wire be to represent the highest mountain range on the globe? How much material must be scraped away from the polar regions to obtain the proper degree of polar flattening?

VIII. Mass of the earth.

1. The earth weighed against a mountain. What were the results and the difficulties of this method.

2. Torsion balance method. Cavendish, Boys, and Braun. What results were obtained by this method?

3. Wilsing's Potsdam method. Describe the methods and give his results.

4. Experiments in deep mines and on mountains.

5. Recent refinements of Torsion Balance method.

IX. Masses of sun, moon, and planets.

1. Planets having no satellites.

2. Planets having satellites.

X. Proofs that the earth rotates.

1. What does the apparent diurnal revolution of the heavens prove?

2. Polar flattening and equatorial bulge.

3. Argument from analogy.

4. Westward deviation of projectiles fired toward equator.

5. Veering of winds, and gyratory motion of cyclones.

6. Eastward deviation of bodies falling from a great height.

7. Foucault's experiment.

XI. Earth's rotatory motion furnishes a convenient scheme for subdividing its surface for detailed study and description.

1. To locate points on a line requires that its distance from a specified point be stated.

2. To locate points on a surface requires the stating of: (*a*) two distances from certain fixed lines; or (*b*) a distance and a direction; or (*c*) two directions from specified lines at certain stated points in these lines.

3. To locate points on the surface of a sphere, as the earth: (*a*) we fix two fundamental reference lines, suggested by the earth's rotation, viz., the equator and the fundamental meridian; (*b*) for convenience, other meridians and a system of parallels are adopted; (*c*) with reference to these circles we fix the positions of points by giving their longitude and latitude; (*d*) derivation of words "longitude" and "latitude," and reason for their present use.

4. Choosing of national meridians a matter of patriotism: (*a*) meridians of Berlin, Paris, Poulkowa, Greenwich, Washington, and Canary Islands; (*b*) recent general adoption of the Greenwich meridian.

5. Fixation of parallels of latitude, and special parallels; (*a*) equator; (*b*) tropics; (*c*) polar circles; (*d*) meaning of these special circles with reference to the sun; (*e*) upon what fundamental does their special positions depend?

6. Interpret the meaning of the meridians: (*a*) with reference to the position of the sun; (*b*) with reference to the time; (*c*) local, siderial, mean, and apparent solar, and standard times; (*d*) time belts; (*e*) beginning of the day.